ARS SPECIAL REPORT

BREEDING BETTER SWINE

Through Performance Testing

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FOREWORD

Pork has traditionally been an inexpensive meat, important in the diet especially of low-income families. Improving the quality and economy of pork year after year by even a small fraction would significantly enrich the diet nationally and raise the standard of living of many people.

The continuing trend in consumer preferences for lean, tender pork and the growing competition from other meats strongly emphasize the importance of developing and applying breeding and testing procedures that will improve the acceptability of pork and the efficiency of producing it. There is ample opportunity to improve a number of swine traits affecting efficiency of production and quality of products. The methods for doing this through breeding are well understood.

Selection of breeding animals based on objective performance records and the choice of a proper breeding plan are the principal tools a breeder has for making the greatest and most rapid improvement in his breeding stock. Testing is the modern substitute for visual appearance in evaluating performance traits.

Research is showing how to get some fairly accurate carcass information on a live hog without impairing the animal's subsequent use for breeding. This is particularly important because of the more rapid genetic progress usually possible by basing selection on the individual's own merit than on its sib or progeny tests.

Research has also supplied estimates of heritabilities and of genetic correlations among different economic traits, as well as information on the expected genetic consequences of different mating systems. These tools add precision to estimates of the rate of progress expected from selection.

The stage has been set for great improvement in swine. Breeders are increasingly engaged in an organized effort for improvement. Adoption of even a fraction of the modern aids to swine improvement by the rank and file of breeders could yield far-reaching benefits to the swine industry and to the well-being of our people.

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BREEDING BETTER SWINE THROUGH PERFORMANCE TESTING

Performance testing can help swine breeders improve the market acceptability of pork and the economy of producing it by providing a more accurate means of identifying genetically superior animals than is possible by purely visual appraisals. Knowing something about the heritability of the various important traits, their genetic and environmental correlations, and their relative economic values, a breeder can exploit recent genetic knowledge to improve the productiveness of his herd and the suitability of its product. The downward trend in consumption of pork relative to other kinds of meat can perhaps be halted and pork be restored to a more favorable competitive position.

Carcass quality is far more important now than it formerly seemed to be. Carcass characters are among the more highly heritable traits and hence can be expected to respond rather quickly to selection. With the market for cooking lard largely gone and consumers discriminating against fat meat, the fat hog is less acceptable in most markets. Moreover, research results show that the leaner hog not only has a higher percent of its weight in the five preferred cuts--hams, loins, bacons, picnic shoulders, and shoulder butts--but also tends to be more efficient in the feedlot and to produce more pigs than the fat hog.

Occasionally, however, hogs having relatively little fat covering also have a relatively low proportion of lean meat. In other words, a relatively high proportion of their body weight is in bones or other non-edible tissues or organs. Such animals are called "meatless" hogs. Low backfat thickness therefore does not automatically assure meatiness.

In recent years, some packers have used market grades in the live animal as the basis for estimating the yield of desirable cuts in the carcass. A few packers pay a premium for the hogs that are judged to be lean, and buy at a discount the ones judged to be fat. Some hogs are being bought on the basis of carcass grade after slaughter. The percentage yield of preferred cuts based on cold carcass weight is an important aspect of carcass grade and in some transactions may make the difference between profit and loss to the producer.

The pressure to produce meatier and cheaper pork doubtless will increase for another reason--the competition from other kinds of meats, especially beef and poultry. Many management and breeding innovations have been made in the production of these alternative meats. Poultry in particular has become relatively more abundant and cheaper. Performance testing for selection of breeding stock is now available to both poultry and cattle breeders and is increasing in use each year. The swine industry must increase the emphasis on performance testing in order to keep its share of the market.

The most convincing reason for performance testing is that improvements resulting from this procedure would be permanent improvements. Such improvements would also more than compensate for the effort and cost involved in the testing.

HISTORIC EXPERIENCE IN BREEDING SWINE

During the early history of this country, a relatively large number of people were engaged in physical labor and required a high-calorie diet such as fat pork provides. Hogs were actually prized most highly for their ability to produce large amounts of fat at relatively light weights. They thrived on a variety of feeds and proved particularly efficient in converting corn into both meat and fat. As settlement expanded in the Midwest, corn proved to be the best crop adapted for the fertile land, and hogs offered the best market for the corn. So corn and hog production became mutually advantageous and interdependent. Hogs that put on heavy layers of fat were especially favored.

Small lard-type hogs were the favorite among breeders of the pure breeds from about 1880 to 1900. Soon after 1900 the small type began to lose its popularity and by 1915 was largely replaced by a type now considered intermediate. The trend toward a still larger type continued to about the middle of the 1920's when pressure for return to an intermediate type got under way. By 1935 the intermediate type once more became the most favored type and has since held this position.

Studies conducted in the middle thirties by the Department and various State Agricultural Experiment Stations on the practical value of small, intermediate, and large-type hogs generally showed that intermediate-type hogs excelled the other two types from the point of view of the producer as well as the packer and the retailer of pork. Intermediate-type pigs required less feed per unit of gain, generally grew faster from weaning to market weight, and produced more desirable carcasses than the other types. Large-type pigs were superior to small-type pigs in most of these characters.

Today there is a strong demand for producing large numbers of truly meat-type hogs.

Genetic studies in the first quarter of this century were primarily concerned with determining the method of inheritance of various qualitative characters such as color, abnormalities, and defects in conformation and demonstrating the validity of the Mendelian laws of inheritance with respect to the transmission of different quantitative traits. It became clear that quantitative traits such as prolificacy and rate of growth are influenced by many more genes--and are much more subject to environmental variations--than are most qualitative traits. The usual methods of determining the mode of inheritance of qualitative characters thus were inadequate in the study of quantitative characters, and new methods were needed to determine the genetic basis of most economically important traits.

One of the more important concepts that evolved in the study of quantitative characters was the degree of heritability of a trait. The heritability of a trait actually is a quantitative expression of the extent to

which variation in that trait is governed by hereditary differences between individuals as compared with the extent to which it is influenced by environmental causes. Knowing the heritability of a trait is important in that it enables a breeder to estimate the change he might expect in that trait from the selection pressure applied.

W. A. Craft, of the U. S. Department of Agriculture, now retired, considers that breeding has contributed to four important achievements in swine production in the past few decades. Hogs now reach market weight of 200 to 220 pounds about 2 months younger than they did 50 years ago. The amount of feed required to produce 100 pounds of gain has decreased by 80 to 100 pounds during that period. More pigs are being saved per litter--about 1.6 more pigs than were saved just 35 years ago. And swine carcasses have been improved some.

As recently as the 1940's it was the goal of progressive swine breeders to produce hogs that would yield 50 percent of their live weight in the five preferred cuts (ham, loin, picnic shoulder, shoulder butt, and belly) at a live weight of 210 to 230 pounds. Many hogs now meet that goal. For example, primal-cut yields increased from about 44 to 50 percent of live weight over the last 30 years in slaughter tests at the U. S. Department of Agriculture's Agricultural Research Center, Beltsville, Md., and from 46 to 48 percent of live weight between 1946 and 1955 in slaughter tests at the Ohio Agricultural Experiment Station.

EVOLUTION OF NEW PRACTICES

Improvement in the efficiency of swine over the past several decades is generally considered to have resulted from both genetic and environmental factors. As some scientists see it, environmental effects are sometimes mistaken for genetic effects. Errors in selection due to environmental effects, such as seasonal differences in weather conditions or changes in feeding and management practices may thus retard improvement. While breeding for type and conformation has considerably improved the appearance of our swine, selection based solely on these traits does not improve the economically important traits to the extent desired because of the low correlation usually found between the former and the latter.

Selection for some traits may cancel the benefits of selection for certain other traits. Negative genetic correlations are believed to be one reason why selection has often been less effective than expected.

Determinations from experimental data of the genetic correlations between various economic traits are becoming increasingly useful. It has been learned, for example, that backfat thickness is negatively correlated with the size of the loin-eye muscle and with the percentage of lean cuts in a carcass. This means that as selection is practiced for low backfat thickness some selection automatically is practiced for larger loin-eye area and for high yield of the lean cuts. Selection for one or the other of these traits would thus be expected to improve all three traits more or less simultaneously.

Ways to Measure Backfat

The relatively high correlations reported among some important carcass traits give added significance to another important advance--the development of instruments for mechanically measuring the thickness of backfat in live hogs. A small calibrated rod or probe is readily passed through fat but stops at the tougher underlying tissue. Reasonably accurate estimates of carcass fat have been made by probing an animal in three locations--behind the shoulders, in the middle of the back, and over the flank at 1-1/2 to 3 inches from the midline of the back. With these instruments, now purchasable on the market, a breeder can use backfat thickness as a criterion in selecting breeding animals at the age of 6 months or less and thereby improve the carcass value of his hogs. Ralph Durham, formerly with the U. S. Department of Agriculture, has estimated that by use of the probe and careful selection, backfat thickness could be reduced by about 0.1 inch per year.

Of course, the amount of fat that a hog produces is partly governed by feeding practices and the weight at which it is slaughtered. A study has shown that each 10 pounds of gain in live weight increases backfat thickness an average of 0.06 inch. This knowledge can be used in adjusting probe readings to a constant weight basis.

Various Factors in Progeny Testing

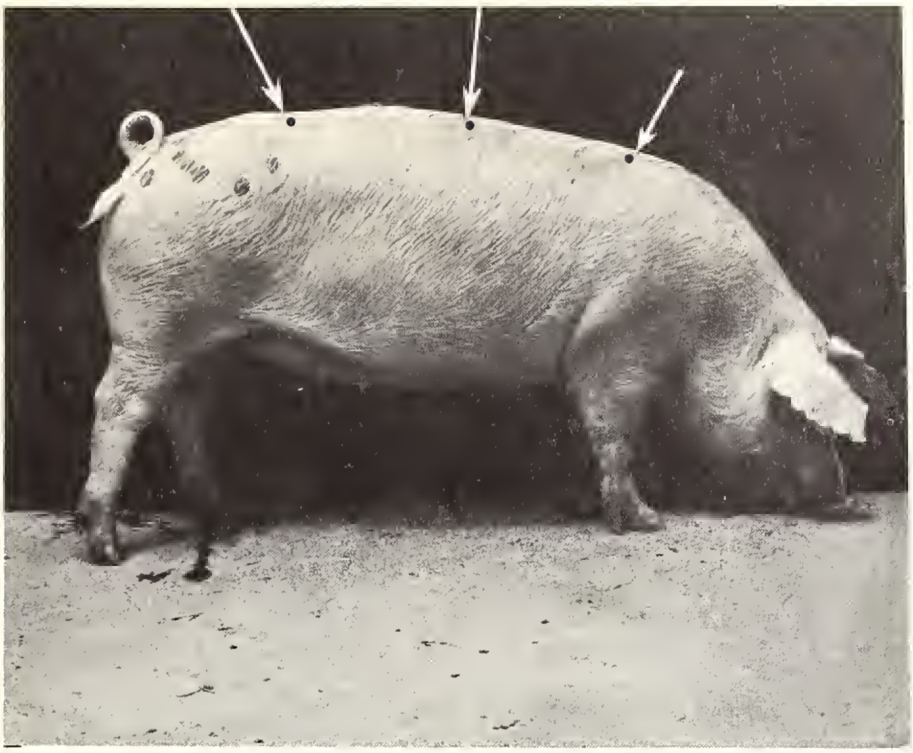
Progeny testing under properly controlled environment is perhaps the most accurate tool for estimating the breeding value of an animal when dealing with traits that are only slightly hereditary. However, progeny testing increases the interval between generations and may thereby lower the rate of improvement.

A few years ago G. E. Dickinson and L. N. Hazel, formerly of the U. S. Department of Agriculture, learned through studies at the Iowa and Nebraska Agricultural Experiment Stations that for maximum progress it is necessary to wean and keep for testing from 8 to 10 times as many boars and about 3 times as many gilts as are needed for breeding. Greatest improvement in sow productivity and growth rate of pigs should occur when one-third to one-half of the gilts are retained for a second litter at about 1-1/2 years of age.

Importance of Heritability

Estimating the heritability of characters in swine has extended the horizons for swine breeding perhaps as much as any other development.

Some of the characters that appear to respond rather well to selection are rate and economy of gain and thickness of backfat. These characters are medium to high in heritability.



BN-14990

Back fat thickness is usually determined at three representative positions along the animal's back, and the measurements are averaged. Arrows show where the thickness is tested in USDA studies at Beltsville, Md.

N-21117

A quick, simple, and inexpensive measurement of backfat can be made with a small calibrated rod or probe. The skin is slit with a scalpel and the probe pressed through the soft fat until it meets resistance on the firm muscle layer underneath.

N-25800

An electronic lean meter records the passage of a current through fat tissue (a poor conductor) until it reaches the lean (a good conductor). The dial translates the conductivity measurement into inches of fat through which the current passed.

Heritability estimates have come from analysis of data from numerous experimental breeding herds studied since about 1930. Heritability estimates reported in the literature for a number of traits are shown as follows:

Character	Average heritability (percent)	Character	Average heritability (percent)
Conformation traits:		Carcass traits:	
Body length	59	Length	59
Length of legs	65	Loin-eye area	48
Conformation score	29	Backfat thickness	49
Type within herds	38	Belly thickness	52
Type between herds	92	Ham, percent of carcass	58
Production traits:		Shoulder, percent of carcass	47
Number farrowed	15	Fat cuts, percent of carcass	63
Number weaned	12	Lean cuts, percent of carcass	31
Litter weight, 5 months	17	Carcass score	46
Pig weight, 5 months	30		
Post-weaning growth rate	29		
Economy of gain	31		

Heritability estimates are especially useful for predicting the rate of improvement that might be made through individual or mass selection. For example, a pig which has made a post-weaning gain of 1.65 pounds a day to 225 pounds live weight in a test group that gained 1.40 pounds a day will on the average transmit factors for 0.07 pound greater daily gain to its offspring compared with the average of the group from which it was selected. That is, 0.29 heritability times 0.25 pound greater gain equals 0.07 pound improvement in one generation. Of course, the actual improvement in the offspring will be the average of this and what it gets from the other parent. Thus, through accurate measurement and selection, even small advantages can add up to major improvements in just a few years.

Organized Swine-breeding Programs

The swine industry has taken a long step forward through formal programs of breed associations for improving important swine traits and through the setting up of numerous breeder organizations using sound testing and selection practices on the farm and at central test stations.

In the late 1930's the swine breed associations began setting up production registeries, offering formal recognition for animals producing superior litters. Thus, in certain breeds sows qualify for production registry if they meet the minimum requirement of 8 pigs in the first litter and 9 pigs in subsequent litters and a minimum weight of 22 pounds per litter at birth. In some other breeds special recognition is given to gilts and sows producing litters of at least 8 pigs weighing 75 to 100 pounds or more per litter (varying between breeds) at 21 days of age. Litters meeting the standards are designated Production Registry Litters (PR Litters). Sows meeting the litter qualifications twice are classed as PR Sows; in some cases they are awarded stars for additional PR Litters.

Most if not all breed associations are now certifying individual hogs that meet standards for three traits: (1) Age at market weight, (2) backfat thickness, and (3) percent of lean meat in the carcass.

Sires are certified as meat sires on the basis of the number of PR Litters they sire which also satisfy meat-type certification requirements.

Wide-scale swine testing began in this country about 1950 under the sponsorship of the State and Federal agricultural extension services. This testing was done at first through on-the-farm swine improvement programs. By 1960, 43 groups in 24 States were operating swine test stations. As an example of the way these stations operate, 24 purebred breeders and 2 commercial hog producers in Illinois set up a test station at a cost of $400 each and had the privilege of testing 4 gilts and 2 barrows at a time, three times a year. The animals are housed and fed under uniform environmental conditions and a standard ration between 60 days and 180 days of age (or to 200 pounds). Eleven such stations in Illinois require an average gain of not less than 1.6 pounds a day and a consumption of not more than 3.2 pounds of feed per pound of gain. The animals must have not over 1.5 inches of backfat to be certified. The requirements vary from State to State but in general are in line with the standards of the breed associations for certification for meat-type litters.

The testing stations are a source of superior sires for use in breeding. The stations are now supplying a substantial number of sires for improving commercial herds in this country.

Testing and certification of meat-type boars has been especially popular. About one-seventh of all boars tested in 1958 met the certification standards for meat type.

HOW CURRENT KNOWLEDGE HELPS TO IMPROVE SWINE

Research has shown that progress through selection depends on several factors--the proportion of animals that are selected for breeding, the amount by which the animals used for breeding excel the average of the group from which they are selected, the number of characters for which selection is being practiced and the method used to measure them, the relative emphasis given to each character, the amount of genetic variation that is available for selection, the nature of genetic correlations, and the selection plan employed. The selection plans available to a breeder are selection based on the animals' own performance, pedigree estimates, progeny testing, sib testing, or on a combination of these plans. Each breeder hopes to make the maximum overall improvement in his swine. That means improving characters which collectively afford the maximum rate of economic gains meeting the market preference. Research has helped in making each of these decisions.

When the characters to be emphasized in selection are decided on and their heritabilities and estimates of genetic correlations are available, the rate of progress expected from a particular selection procedure can be judged. Type and accuracy of selection determine how fast improvement may progress.

RESULTS OF SIX GENERATIONS OF BREEDING FOR BACKFAT

RANDOM SELECTED (CHECK)

BN-14921

Check gilt averaged 1.30 inches of backfat when probed at 175 pounds live weight, and 1.65 inches when slaughtered at 209 pounds. Its carcass measured 29.1 inches from aitch bone to first rib.

SELECTED FOR LEANNESS

BN-14922

Lean gilt averaged 1.13 inches of backfat when probed at 175 pounds live weight, and 1.42 inches when slaughtered at 220 pounds. Its carcass measured 31.3 inches from aitch bone to first rib.

BN-14920

Check gilt at slaughter yielded 9.3 pounds of lean meat in the right ham, 9.6 percent of its live weight in bacon, and 11.8 percent in fat cuts. The loin eye measured 4.31 square inches.

BN-14923

Low-fat gilt at slaughter yield 10.8 pounds of lean meat in the right ham, 10.8 percent of its live weight in bacon, and 9.3 percent in fat cuts. The loin eye measured 4.65 square inches.

The improvements most widely sought by breeders and market hog producers are increases in litter size and survival to weaning, in rate and economy of gain from weaning to slaughter age, in the proportion of preferred cuts in the total carcass, and decrease in backfat thickness.

Heritability estimates are central reference points for all other decisions, since they measure how much of the observed difference in a character between individual animals is due to breeding and how much is due to environment. Above all else, the breeder must recognize and properly evaluate the heritable effects. Environmental effects may, of course, introduce errors by making individuals appear to be more or less meritorious than they would be under uniform environmental conditions. In order to minimize such errors, it is important to standardize environmental conditions and to adjust performance data for measurable differences that were not controlled.

Which Traits to Improve

Breeding to improve a single trait might be useful where that trait is seriously deficient. However, selection generally is practiced for several traits at the same time. The greater the number of traits to be selected for, the less the intensity of selection and the slower the progress for any one of them. Rate of progress would be reduced to the factor 1 divided by the square root of the number of traits under selection. Thus, simultaneous selection for four noncorrelated and equally important traits would reduce progress for each to 1/2 the progress expected from single-trait selection. Selection for fancy points on the conformation scorecard reduces the progress for all other characters. Nevertheless, simultaneous selection for 4 equally valuable traits would be expected to improve net merit more rapidly than selection for only one trait at a time.

Naturally a trait such as body length, with a heritability of about 59 percent, will respond to selection more rapidly than one such as number of pigs farrowed, with a heritability of only about 15 percent. Regardless of which traits are emphasized in selecting breeding stock, some improvement will also be made in other traits in which the breeding animals excel their group.

As noted above, the rate of improvement also depends on the proportion of the population that is saved for breeding and the amount by which the selected animals exceed the average of the group from which they were chosen.

Evaluating Traits

An individual's own performance or apparent merit always receives some, if not primary consideration, in the selection of breeding stocks. This is true especially for traits such as rate of growth, efficiency of feed utilization, conformation score, and type, because information on these traits usually is available by the time the animal reaches breeding age of about 8 months. However, relatives such as full sibs or half sibs or even an ancestor or progeny may give valuable additional information.

A boar's breeding value for a trait such as litter size must be estimated from information on his dam, his sisters or half sisters, or his daughters. The breeding value of a boar for mothering and milking ability

is similarly rated by the weaning weight of the litter in which he was born and of the litters produced by his sisters or daughters.

For traits that can be measured only after slaughter, such as yield of preferred cuts, size of loin eye, or other carcass traits, selection based on the carcass measurements of half sibs and full sibs becomes the most efficient method of improvement.

Information from relatives is most useful when dealing with traits that have low heritabilities. In those cases the additional accuracy gained may be important enough to justify sib or progeny testing. And when efficiency of production or quality of product is at stake, a small extra improvement often repays the extra effort of applying the best techniques.

It sometimes expedites improvement, for example, to select young individuals on the basis of an estimate or inconclusive evidence of their merit and then supplement this information with information on close relatives.

Choice of Traits Affects Breeding Progress

Circumstances that tend to delay selection by increasing the interval between generations must be examined critically. The shorter the interval between generations can be kept, the faster the potential rate of progress. As was pointed out earlier, selection for traits that become manifest in an animal before it reaches breeding age may result in a new generation every 12 months. The same replacement schedule is possible with selection based on sib testing. Selection for traits expressed only in females, such as litter size or litter weight at birth, extends the interval between generations to about 18 months when it is based on sib testing, and to about 2-1/2 years when it is based on progeny testing. And progeny testing for carcass characters provides a new generation about every 24 months.

G. E. Dickinson and L. N. Hazel, former researchers of the U. S. Department of Agriculture, showed nearly 2 decades ago that selection based on progeny testing may retard rather than increase the rate of progress.

Methods of Making Selections

Hazel and Jay L. Lush explored the theoretic consequences of three methods of selection aimed at improving several traits simultaneously.

One of these methods is called <u>tandem selection</u>. It is directed toward improving one trait to a satisfactory level, then a second, and subsequently other traits are improved. This method is easily applied and allows a breeder to make final selection as soon as the particular trait can be measured. The disadvantages of this plan are that an animal's value seldom depends on one trait only, and that selection for a single trait at a time may result in deficiencies in others.

The second method employs <u>independent culling levels</u>--a certain minimum level of merit for each trait. All individuals performing below the established level for a particular trait are discarded regardless of superiority in other traits. This plan has the advantage of permitting culling of animals for characters that can be measured early in life, but

it does not allow for the retention of animals distinctly superior in some traits, if they are below the pre-determined level for others.

The third method, selection by index or total score, evaluates the total animal on its performance in all of the chosen traits. The index is a numerical expression computed by taking into account the heritabilities and relative economic values of the various traits, as well as their genetic and phenotypic correlations.

Several experiment stations have developed selection indexes and are now trying them in their breeding programs. The traits most generally considered in constructing these indexes have been sow productivity as measured by litter size and litter weight, growth rate, and backfat thickness at a standard age or weight. As backfat decreases, the percentage of lean cuts increases. Thus, backfat thickness, measured in the live animal, provides an indirect measure of the percentage of lean cuts, which can be estimated with relatively low accuracy in the live animal.

It is possible, of course, to do concurrent selection on several traits while giving equal emphasis to all of them. The most effective indexes, however, give appropriate weights to the economic value and heritability of each trait and to its genetic and phenotypic correlation with other traits.

FUTURE PROSPECTS

At no time has the future for swine breeding appeared brighter or the need for improvements in breeding practice greater. New genetic knowledge offers rewards to those who use it.

Although crossbreds generally outperform their parents in such traits as litter size, pig vitality, growth rate, disease and parasite resistance, and feed efficiency, a breed may differ in its combining ability with other breeds. Moreover, the hybrid vigor exhibited by the offspring from the crossing of two breeds may vary with the particular strains used for crossing. Extensive research is needed to guide market hog producers in selecting breeds and strains for crossing.

Recent genetic knowledge has not been adequately exploited. The swine industry can take a long step forward by widely adopting the breeding systems and selection methods that are now known to be best suited under various conditions. Current studies of selection within mildly inbred lines versus interline selection should help breeders of purebreds avoid the pitfalls of inbreeding.

Improvement from selection within the pure breeds is likely to be greatest for traits that received least attention in the past--the ones showing relatively large amounts of genetic variation.

Many experiment stations are conducting basic research to learn more about principles of genetics. This work should widen the horizons for the industry. A number of stations also are evaluating the needs and present opportunities for improving specific traits. What the U. S. Department of Agriculture and State agricultural experiment stations do over the next two or three decades and the extent to which professional breeders use basic information now available will determine how much progress the swine industry can make.

Selection for some traits may lead to deficiencies in others. If such negative correlated responses are large, better opportunities may lie in the development of strains of swine having high crossing values with one another.

The importance of differences in blood types in swine is little understood. Some blood groups in poultry seem to be associated with certain performance traits. Geneticists are looking for just such a simple test as blood typing for inexpensive and early judgment of the productive potential of swine.

State experiment stations are trying to improve testing techniques, too. Some of the objectives are to estimate an animal's breeding value earlier in life, to increase the heritability of individual traits by minimizing hitherto uncontrolled environmental differences, and to lower testing costs. Anything that improves the effectiveness and economy of testing stations will have far-reaching effects, for those stations constitute an important source of boars for breeding. Selecting superior sires is especially important because of the larger number of offspring usually produced by a boar than by a sow.

Some studies deal with the extent to which litter size is determined by the number of ova produced during estrus, by nutritional differences during embryonic development, and by hereditary differences affecting embryonic survival rates. Closer coordination of physiologic and genetic research should give us a better understanding of the nature of variation in litter size. That in turn may enable us to better control the more important environmental sources of variation and thereby increase the effectiveness of selection.

Artificial insemination, which enables dairymen to widely use the best germ plasm based on performance testing, has been used to only a very limited extent in swine breeding. Part of the problem is the perishability of swine semen as presently processed. Several experiments are devoted to finding better means of preserving the semen during storage and shipment. Studies are also being made of the possibility of artificially inducing estrus with hormones so several sows can be inseminated at the same time. To succeed, the hormone treatment must induce not only the physiological symptoms of estrus, but also actual ovulation.

When artificial insemination becomes practical, it will be all the more important to identify genetically superior sires. Testing stations and tested herds are the logical source for these sires. And the index or total-score procedure is the best means of identifying sires with the best aggregate of important traits.

The question arises how to make sure that all of the best swine families and best individual hogs become available for stud service. Some geneticists think that testing should be limited to a few herds known to be best, with the view of continually improving those herds and using them as the source for breeding stock for other breeders. Other geneticists think that rigid testing and selecting should be extended to the entire swine population. It seems that the industry would advance farthest and fastest if test stations admit only the number of hogs that can be tested comprehensively, getting as many as possible from the very elite herds.

Variations in testing environments and differences in climatic conditions prevent direct comparison of individual merit between animals tested in different stations or at the same station in different years. But the degree of superiority of individuals over the average record of the groups to which they belong is a good measure of individual differences in genetic metit.

Breeding associations are accepting only purebreds in their test stations and on-the-farm testing programs. Some geneticists think the testing should also be opened to first- and second-generation crossbreds.

Experimental and test data of these kinds should point to the best cross-breeding practices and the best sources for purebred farm sires and sows for crossing, and enable market hog men to improve the efficiency and quality of their swine.

The many important breeding developments of today foretell a bright future for the swine industry.

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Growth Through Agricultural Progress